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Growth and Yield of Well-Stocked Aspen and Birch Stands in Alaska

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GROWTH AND YIELD OF WELL-STOCKED ASPEN AND BIRCH STANDS IN ALASKA[1]

by

Robert A. Gregory[2] and Paul M. Haack[3]

INTRODUCTION

When the Northern Forest Experiment Station began its research program for Alaska's interior Forests in 1957, the most frequently asked questions concerned (1) the composition and quantity of the existing timber resource, and (2) the land's inherent ability to produce timber. The Station's current inventory will provide information on the first, and a partial answer to the second is in this report.

Quaking aspen (*Populus tremuloides* Michx.) and paper birch (*Betula papyrifera* Marsh.) growth and yield data presented here are based upon well-stocked, even-aged stands sampled during the past several years. The data are in the form of normal yield tables, a familiar working tool to most foresters. The use of such tables in present-day management is limited because of the subjectivity involved. Nevertheless, the tables do provide an excellent means to illustrate the development of well-stocked stands, the effect of site upon yield, and the range of site classes within a forest region. Our objective was to illustrate these characteristics.

THE FOREST REGION

Interior Alaska embraces the area between the Brooks Range on the north and the Coastal Range, bordering the Pacific Ocean, on the south (Lutz 1956). It is an extension of the Boreal Forest Region of Canada, which forms a continuous belt from Newfoundland and the Labrador coast westward to the Rocky Mountains and northwestward into Alaska (Rowe 1959).

1/ The study was conducted from the Station's Forestry Sciences Laboratory, College, Alaska, maintained in cooperation with the University of Alaska.

2/ Leader, Interior Silviculture Project

3/ Formerly Station Biometrician and now at the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

The Interior is a unique forest region in several respects. The short growing season and extremely low winter temperatures are obvious environmental factors.[4/] The region is mostly within the zone of discontinuous permafrost, the occurrence and depth of which is conditioned largely by drainage, aspect, and presence or absence of insulating organic layers on the soil surface. Precipitation is low for a forested region (10-13 inches annually), but occurs during the growing season more than at other times of the year. Day length is almost continuous throughout June, when growth of tree stems is greatest. Strongly superimposed upon these factors is the high incidence of wildfire so common to forests of northern interior regions (Lutz 1956, 1959).

Quaking aspen, paper birch, white spruce (*Picea glauca* (Moench) Voss), and cottonwood (*Populus balsamifera* L. and *P. trichocarpa* Torr. and Gray) are the commercial tree species. Black spruce (*Picea mariana* (Mill.) B.S.P.), though abundant, rarely reaches merchantable size. Larch (*Larix laricina* (Du Roi) K. Koch) frequently occurs in open, poorly drained areas, but is apparently unable to compete on the better sites and seldom exceeds four to six inches d.b.h.

Preliminary forest inventory estimates for the Interior show that about one-third (106 million acres) of the land area is forested and approximately one-fifth of the forest area is classed as commercial forest land capable of producing annually at least 20 cubic feet of wood per acre. Although white spruce and cottonwood occasionally exceed 30 inches d.b.h. and 100 feet in height, most trees are small and yields are modest in comparison with regions farther south.

ORIGIN AND DEVELOPMENT OF ASPEN AND BIRCH STANDS

Both aspen and birch are short-lived pioneer upland species. They occupy rather specific physiographic positions and usually do not occur together. Aspen is limited chiefly to southern exposures while birch predominates on northeast- and northwest-facing slopes (fig. 1). Both species characteristically invade burned-over areas, rapidly forming even-aged pure stands that develop from seed, suckering of aspen roots, or sprouting of birch. Most trees in the sampled aspen stands originated from root suckers

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4/ For a detailed description of the climate of the region see: Watson, C. E., Climates of the States, Alaska. U. S. Dept. of Commerce, Weather Bureau, Climatograph of the United States No. 60-49, 24 pp., 1959.

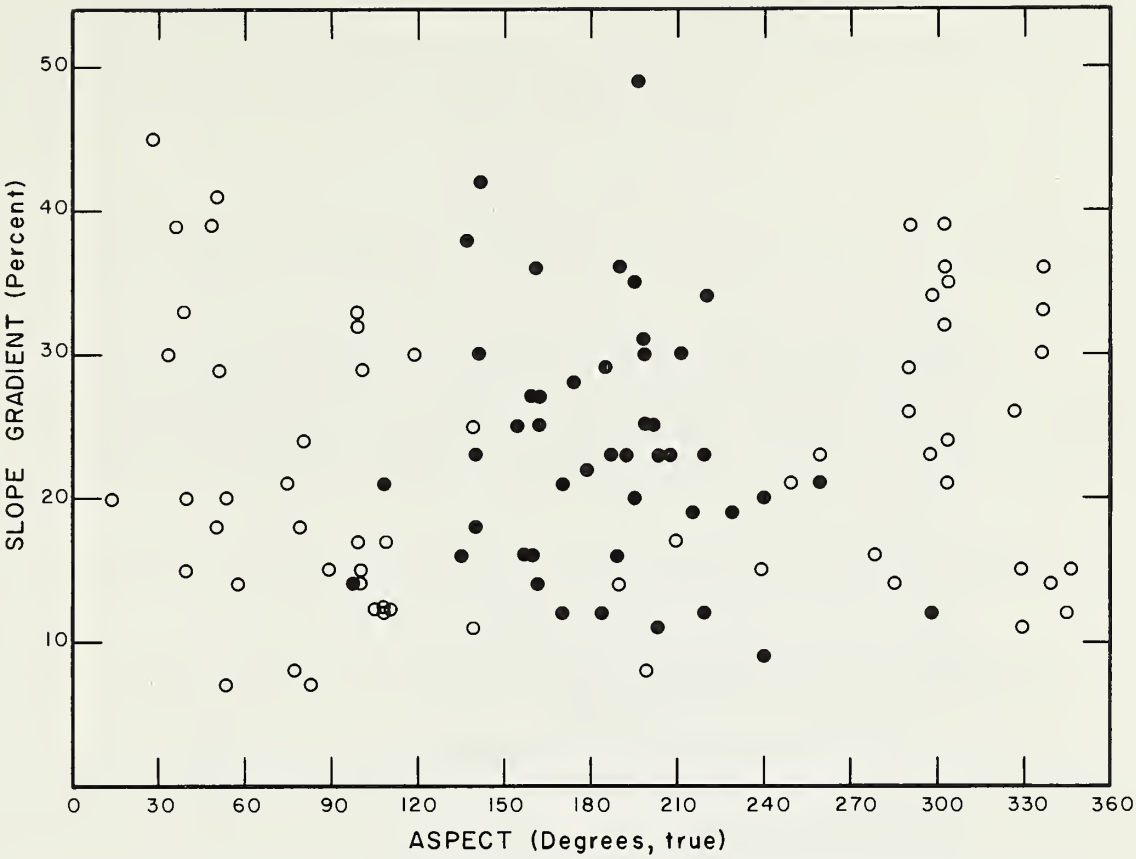

Figure 1.--Distribution of sample plots by slope and aspect on slope gradients greater than 5 percent and at elevations less than 2,000 feet. Black circles represent aspen; white circles, birch.

while the majority of birch stands were of seed origin. White spruce often becomes established with aspen or birch but usually remains in an understory position for many years.

Under favorable conditions, stocking of young stands is extremely dense (table 9), early growth is comparatively rapid, tree crowns close at an early age, and mortality, due to shade intolerance, is high; few stems occupy a suppressed position. Both species are highly susceptible to pathogens; stands reaching 90 to 100 years of age typically begin to disintegrate. White spruce, if present, then occupies a dominant position, further hastening deterioration of the pioneer hardwoods.

Although both species are susceptible to infection and decay by pathogens, they appear to remain intact and free of serious decay in Alaska longer than in more southern regions. Some serious pathogens such as *Hypoxylon pruinatium* have not been found here, and it seems apparent that the rate of

decay caused by others proceeds more slowly. Many sectioned aspen trees up to 100 years old showed little or no decay.

GROWTH AND YIELD

TERMS AND MEASURES

Age.--Average age of selected dominant and codominant trees. Total age was used for aspen, and b.h. age (age at 4.5 feet above ground level) for birch.

We wished to use total age for both species. However, staining and decay at ground level often obscured annual rings in old birch stands. Estimates of total age from b.h. age proved unreliable because the average number of years required for birch seedlings to reach b.h. was found to vary greatly between stands.

Height.--Total height of the tree of mean basal area among dominant and codominant trees.

Site index.--Height of the tree of mean basal area among dominant and codominant trees at index age 50 years.

Volume.--All volume units are in cubic feet. Board-foot measure was purposely omitted because the small diameter trees that predominate are more accurately measured in cubic feet.

Tree volume equations used for computing per-acre volumes have been published previously (Gregory and Haack 1964).

Per-acre volumes of the stand segment consisting of trees 4.6 inches d.b.h. and larger are based upon measurements of entire peeled stems from a 1-foot stump to a 4-inch top; those for the stand segment consisting of trees 6.6 inches and larger, upon measurements of entire peeled stems from a 1-foot stump to a 6-inch top.

BASIC DATA

Seventy-nine aspen and 108 birch plots were sampled throughout the Interior. Plot number per stand ranged from two to six depending upon stand size and variability; more plots were taken in large stands where variability in site class was apparent. Plot area ranged from 1/20 to 1/2 acre, smaller for young stands and larger for those of greater age. There were at least 100 trees on all plots.

For a plot to qualify as well stocked, the crown cover had to be nearly complete. Small holes (gaps not exceeding the crown width of a dominant tree) were acceptable and frequently occurred. With these liberal standards the

selection of plots was not difficult. An expression of stocking based upon the sample data is shown in figures 2 and 3.

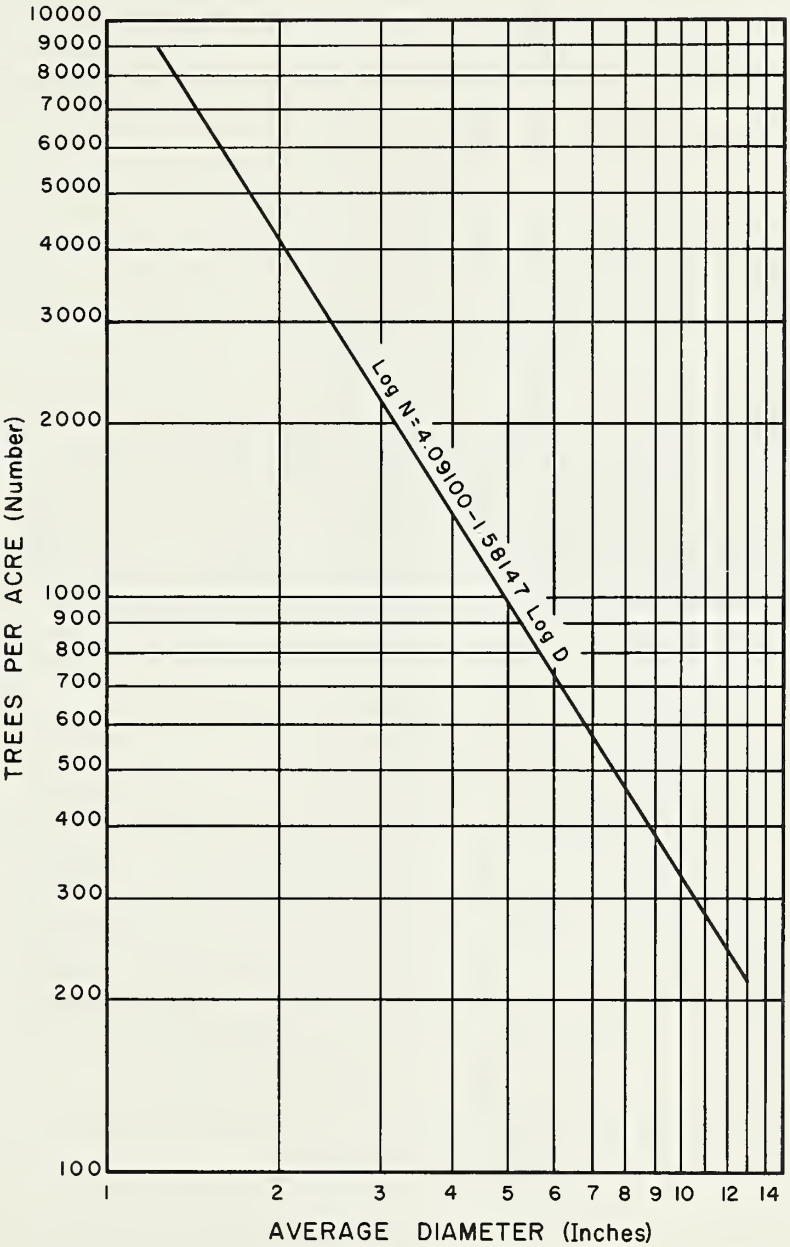

Figure 2.--Number of aspen trees per acre over average stand diameter, trees 0.5 inch d.b.h. and larger.

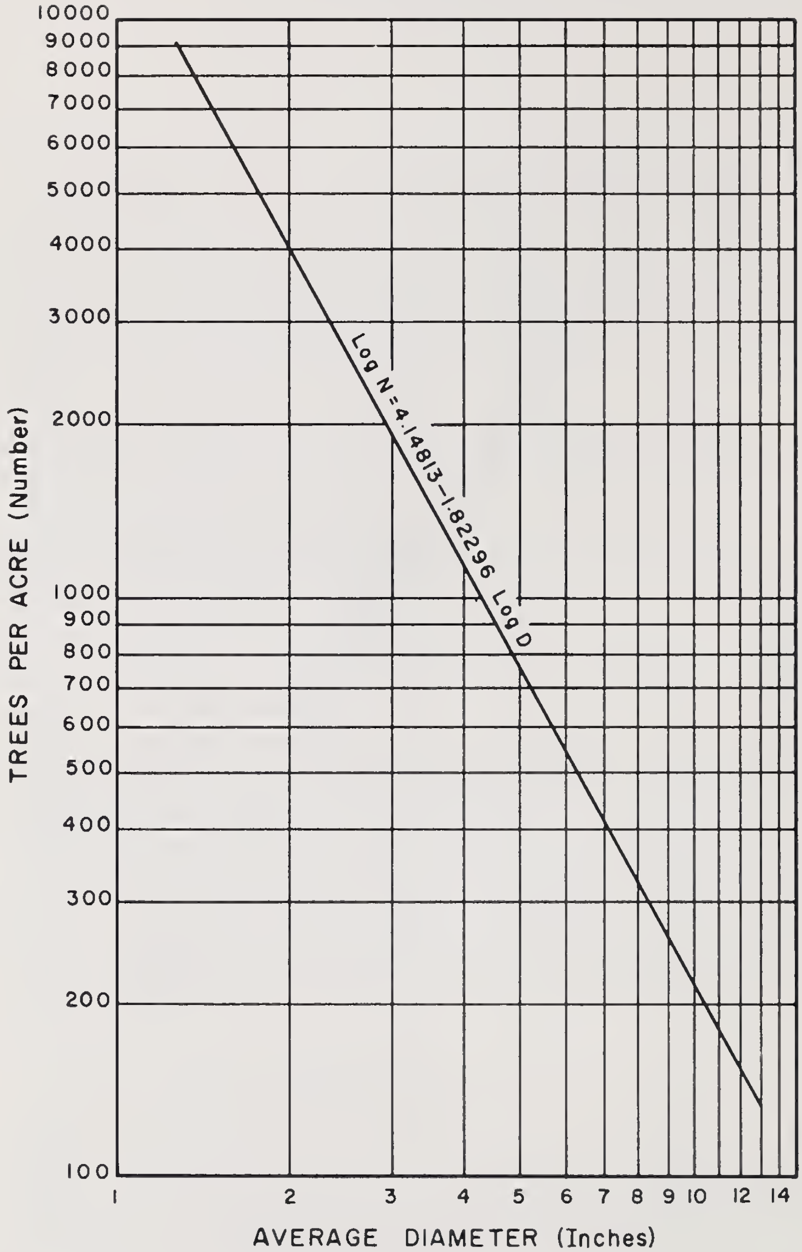

Figure 3.--Number of birch trees per acre over average stand diameter, trees 0.5 inch d.b.h. and larger.

Stand age was determined by averaging ring counts from at least six dominant and codominant trees.

Data taken on each plot included:

1. Diameter of all live trees 0.6 inch d.b.h. and larger by 1-inch classes.

2. Crown class of all live trees.

3. Enough total height measurements (a minimum of ten and at least two in each diameter class) to construct a reliable height-diameter curve.

4. A description of the plot including latitude, longitude, physiography, aspect, slope, and elevation.

On 14 of the aspen plots in older age classes, two to four trees closely corresponding to the tree of mean basal area among dominants and codominants were felled and sectioned for height-over-age data. These data, from 43 trees, were later used in constructing site index equations.

No well-stocked stands of aspen in the older age classes were found on the better sites (table 1). One would expect only a few such stands in a normal population of site indices throughout the range of ages. The few that would normally occur in older age classes have apparently been reduced by the high incidence of wildfire around centers of population and routes of travel during the early part of this century. Therefore, aspen growth and yield values have not been extended to 100 years in the high site index, older age class ranges.

ANALYSIS

Site index.--We derived the equation and computed the family of site index values for aspen (table 2, fig. 4) using the methods of Johnson and Worthington (1963), with one exception. The stem analysis data indicated that aspen displayed uneven rates of height growth for different sites at specific ages. The regression coefficient, b, decreased until age 50, the index age, then slowly increased in curves of site index over height at specific age classes. Normally, a straight line of the form $y = b_o + b_i x$ should result where $y = (b - 1)$ and $x = (1/\text{age} - 1/50 \text{ years})$. With aspen, however, a slight upward bend was noted. To adjust this, the curve form was extended to the second degree polynomial, resulting in the final estimating equation:

$$\text{site index} = \text{height} \left[b'_o + b'_1(1/\text{age}) + b'_2(1/\text{age}^2) \right].$$

Reliable height-over-age curves from individual stem sections could not be prepared for birch as for aspen. Birch site index curves (table 2, fig. 5) were therefore constructed using the older methods of Bruce and Schumacher

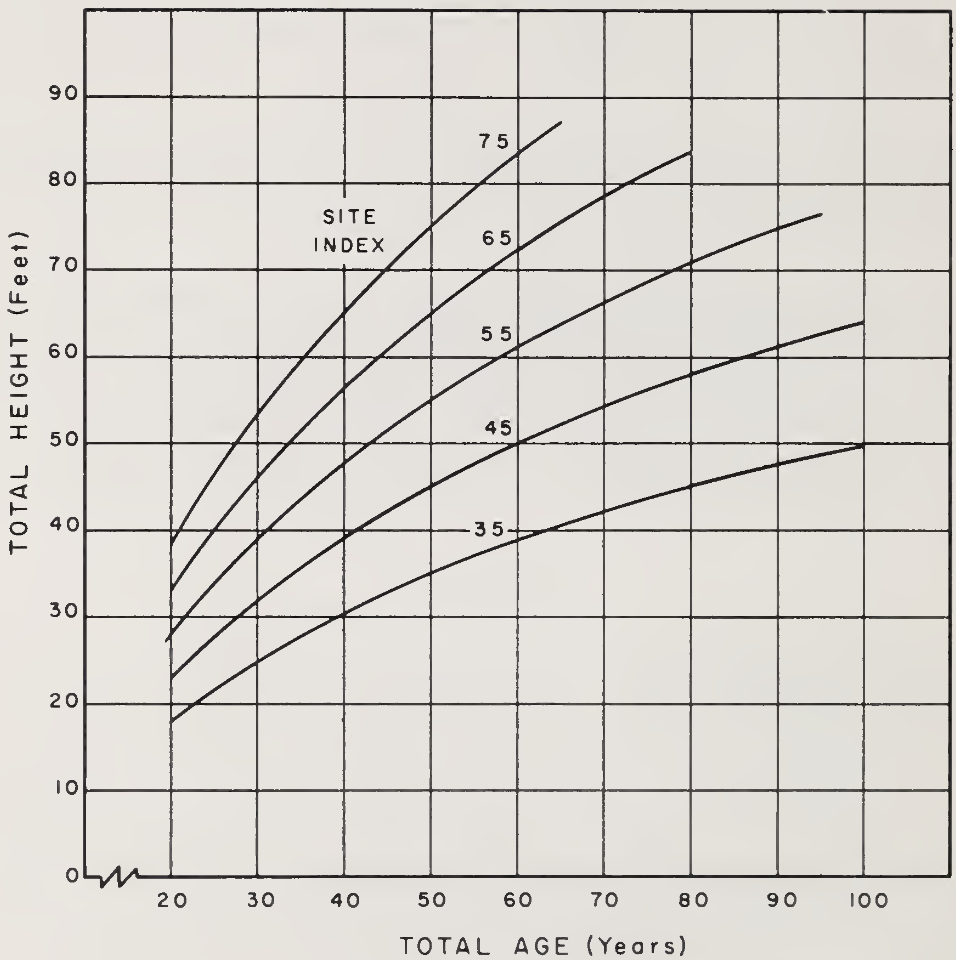

Figure 4.--Average total height of dominant and codominant aspen trees.

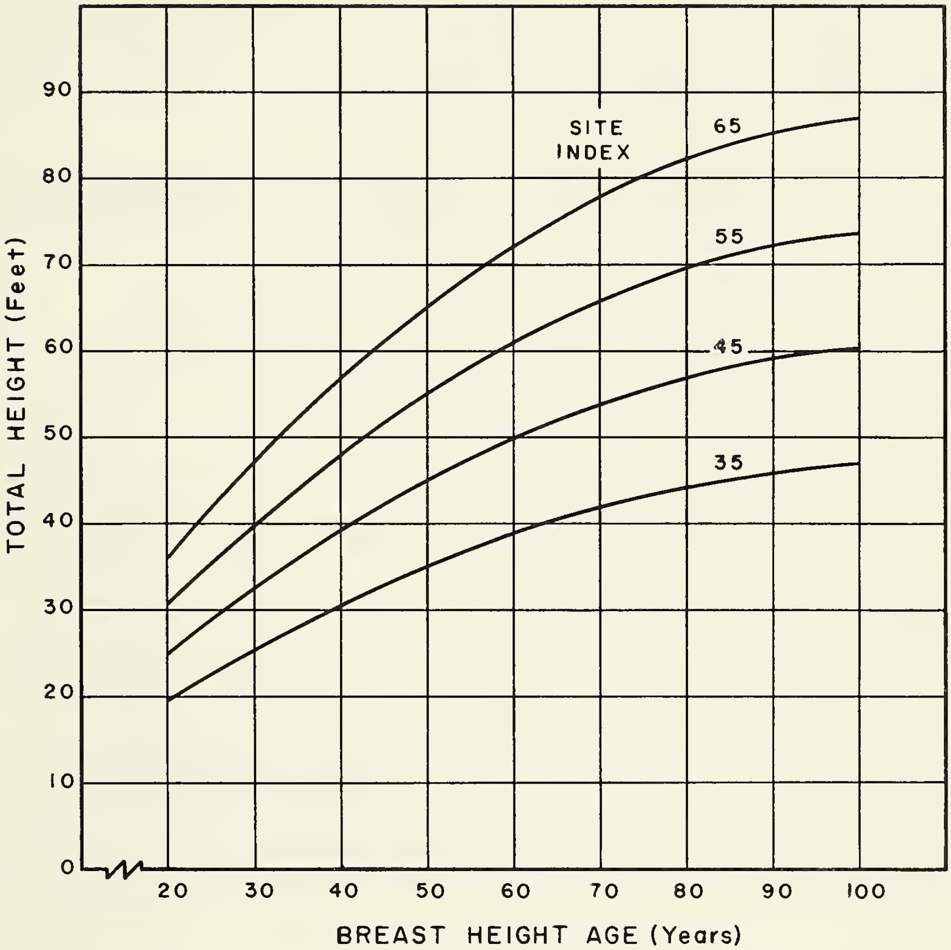

Figure 5.--Average total height of dominant and codominant birch trees.

(1950). The guide curve was fitted to the sample plot data with a least-squares solution for a second degree polynomial equation. The coefficient of variation of the sample data around the guide curve did not relate to age, so fixed percentage deviations from the guide curve were used to construct the family of curves. Expressed in equation form,

$$\text{height} = \frac{\text{site index (guide curve equation)}}{\text{guide curve height at index age 50 years}} .$$

This was reduced to the site index predictor form shown at the bottom of table 2.

Yield estimates.--Equations to estimate basal area per acre, basal area of the average tree, and volumes per acre (tables 3 through 13) were derived by using the stepwise regression system of Boles.[5/]

The resultant equation is accepted as the best combination of the presumed reasonable independent variables. Calculations were made on an IBM 1620 computer. The basic equation involved was:

$$Y_i = b_o + b_1A + b_2A^2 + b_3A^3 + b_4S + b_5S^2 + b_6S^3 + b_7SA$$

$$+ b_8SA^2 + b_9S^2A + b_{10}S^2A^2 + b_{11}1/A$$

where:

Y_1 = Basal area per acre for trees larger than 0.5 inch d.b.h.

Y_2 = " " " " " " " " 4.5 inches d.b.h.

Y_3 = " " " " " " " " 6.5 inches d.b.h.

Y_4 = Average basal area of trees larger than 0.5 inch d.b.h.

Y_5 = " " " " " " 4.5 inches d.b.h.

Y_6 = " " " " " " 6.5 inches d.b.h.

5/ Boles, J. N. 40-series-stepwise regression system. Calif. Agr. Expt. Sta., Dept. of Agr. Econ., U. of Calif., Berkeley, 43 pp. dittoed. June 1962.

Y_7 = Cubic-foot volume per acre for trees larger than 4.5 inches d.b.h.

Y_8 = " " " " " " " " 6.5 inches d.b.h.

A = Stand age · · · total age for aspen; b.h. age for birch.

S = Site index.

b_j = Regression constants.

We found the diameter of the tree of mean basal area, D, by solving:

$$D = \sqrt{Y_i/0.005454}$$

where $Y_i = Y_4$, Y_5, or Y_6, as defined above.

The number of trees per acre for the three stand components, N_i, was estimated according to the above definitions by solving:

$$N_1 = Y_1/Y_4,\ N_2 = Y_2/Y_5,\ \text{and}\ N_3 = Y_3/Y_6.$$

Some merging occurred at high site indices and ages between birch equations Y_1 and Y_2; Y_1 and Y_3; and also between aspen equations Y_1 and Y_2. At points of merging, the more precise Y_1 values were substituted. Equations for merging age were calculated by: (1) plotting values for Y_1, Y_2, and Y_3 over age within site classes; (2) reading the age at the intersection of these freehand curves for the same site indices; and (3) regressing this merging age on site index as a second degree polynomial or a logarithmic function.

Footnotes to the tables show the equations calculated as explained above, and the precision of them in terms of R^2, the multiple coefficient of determination.

Diameter frequencies.--Tables 14 and 15, which show relative distribution of tree diameters by average stand diameter, were prepared using the graphical method of constructing stand tables described by Meyer (1937). The two tables may be used to estimate the number of trees in any diameter class of a well-stocked stand, when age and site index are known, by cross reference to tables 6 and 9.

ESTIMATING SITE INDEX

Equations for estimating site index have many applications in both forest land management and research. They may be used whenever estimates of forest land productivity are desired, providing, of course, there is at least a moderately well-stocked stand available for obtaining the age and height

variables needed in the equations. These variables are easily obtained in the field.

Average stand age can be calculated from increment borings of several standing trees or from cross sections of felled trees. If necessary, total age of aspen can be closely approximated by arbitrarily adding three years to b.h. age.

To simplify field estimates of height, linear regressions relating average maximum stand height, H_m, to the height corresponding to the tree of mean basal area among dominants and codominants, H, were prepared from the sample plot data. The two resulting equations expressing this relationship are:

1. Aspen H[6/] $= -3.42 + 0.98030\ H_m$

2. Birch H[7/] $= -4.89 + 0.99972\ H_m$

H may thus be estimated from H_m by measuring and averaging the total heights of at least three of the largest diameter trees in the stand. Unusually large trees that have developed in an open situation should be avoided. Since the "b" coefficients in both of the above equations are so close to 1.0, H may be obtained by simply subtracting 3.4 feet from aspen H_m or 4.9 feet from birch H_m.

Finally, to estimate site index, it is only necessary to substitute the age, A, and height, H, variables in the appropriate species equation given at the bottom of table 2.

6/ $R^2 = 0.972$
7/ $R^2 = 0.964$

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Table 1.--Distribution of sample plots by age and site index

Age (years)	Species	Site index (feet)									Total
		<35	35-39	40-44	45-49	50-54	55-59	60-64	65-69	>69	
		Number of plots									
20- 39	Aspen	--	2	1	4	1	2	2	--	--	12
	Birch	1	--	6	4	9	1	3	--	--	24
40- 59	Aspen	4	3	6	6	5	3	3	4	5	39
	Birch	--	--	--	2	4	8	3	--	--	17
60- 79	Aspen	--	2	2	5	2	3	1	1	--	16
	Birch	--	4	6	4	12	5	3	--	--	34
80- 99	Aspen	1	2	--	2	5	1	--	--	--	11
	Birch	--	--	1	5	13	3	--	--	--	22
100-119	Aspen	--	--	--	--	1	--	--	--	--	1
	Birch	--	--	--	4	4	3	--	--	--	11
Total	Aspen	5	9	9	17	14	9	6	5	5	79
	Birch	1	4	13	19	42	20	9	--	--	108

Table 2.--Average total height of dominant and codominant trees

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Feet								
20	19	25	31	36	18	23	28	33	38
25	22	29	35	42	21	28	34	40	46
30	25	33	40	47	25	32	39	46	53
35	28	36	44	52	28	36	44	51	59
40	30	39	48	57	30	39	48	56	65
45	33	42	52	61	33	42	52	61	70
50	35	45	55	65	35	45	55	65	65
55	37	48	58	69	37	48	58	69	79
60	39	50	61	72	39	50	61	72	83
65	40	52	63	75	41	52	64	75	87
70	42	54	66	78	42	54	66	78	--
75	43	55	68	80	44	56	69	81	--
80	44	57	69	82	45	58	71	84	--
85	45	58	71	84	46	60	73	--	--
90	46	59	72	85	48	61	75	--	--
95	46	60	73	86	49	63	77	--	--
100	47	60	74	87	50	64	--	--	--

Tabular values were derived from the following equations:

$$\text{Birch site index} = H/\ (0.16 + 0.021845A - 0.0001006A^2)$$

$$\text{Aspen site index} = H\ (66.81/A^2 - 27.6197/A + 0.4209)$$

Table 3.--Basal area per acre of trees larger than 0.5 inch d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Square feet								
20	--	--	--	--	68	74	81	87	93
25	--	--	--	--	73	81	89	96	103
30	70	84	98	112	79	88	97	105	112
35	72	86	101	115	84	95	104	113	121
40	75	89	103	117	90	101	111	120	128
45	76	90	105	119	95	107	117	127	135
50	78	92	106	120	100	112	123	132	140
55	79	93	107	121	104	117	129	138	145
60	80	94	108	122	109	122	133	142	149
65	80	95	109	123	113	127	138	146	152
70	81	95	109	124	117	131	142	149	--
75	82	96	110	124	121	135	145	152	--
80	82	96	110	125	124	138	148	153	--
85	83	97	111	125	128	141	150	--	--
90	83	97	111	126	131	144	152	--	--
95	84	98	112	126	134	146	153	--	--
100	84	98	112	126	137	149	--	--	--

Birch basal area $= 40.49 + 1.41222\ S - 612.38106/A$

$R^2 = .469$ Basis, number of plots = 108

Aspen basal area $= 42.30 + 0.3849\ SA - 0.0000032991\ S^2A^2$

$R^2 = .570$ Basis, number of plots = 79

Table 4.--Basal area per acre of trees larger than 4.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Square feet								
30	--	--	--	20	--	--	--	20	41
35	--	--	17	39	--	--	16	40	63
40	--	--	32	56	--	--	32	59	85
45	--	20	47	71	--	19	48	77	106
50	--	31	59	84	--	31	63	95	127
55	--	42	71	95	--	42	77	112	145
60	--	52	81	105	17	54	91	128	149
65	25	60	90	112	25	64	104	143	152
70	32	68	97	118	33	74	116	149	--
75	38	75	103	122	40	84	128	152	--
80	44	80	107	124	47	93	139	153	--
85	49	85	110	125	54	102	150	--	--
90	53	89	111	126	61	110	152	--	--
95	56	91	112	126	67	118	153	--	--
100	59	93	112	126	72	125	--	--	--
	Years								
Merging age	--	--	88	82	--	--	84	67	55

Birch:

Below merging age: Basal area = $-130.96 - 0.00469\ A^2 + 0.09440\ SA - 0.0000076035\ S^2A^2$

$R^2 = .923$ Basis, number of plots = 96

Above merging age: same as table 3.

Merging age = $600.05 - 16.70121\ S + 0.13432\ S^2$

Aspen:

Below merging age: Basal area = $-112.92 + 0.07489\ SA - 0.00022\ SA^2$

$R^2 = .883$ Basis, number of plots = 65

Above merging age: same as table 3.

Log_{10} merging age = $4.36549 - 1.40174\ \text{Log}_{10}S$

Table 5.--Basal area per acre of trees larger than 6.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Square feet								
30	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	32
40	--	--	--	24	--	--	--	20	46
45	--	--	--	28	--	--	--	33	62
50	--	--	--	40	--	--	--	48	80
55	--	--	8	55	--	--	28	63	99
60	--	--	19	72	--	--	41	80	119
65	--	5	32	88	--	13	55	97	139
70	8	15	45	102	--	25	70	115	--
75	15	25	57	114	--	36	85	133	--
80	22	36	68	124	--	48	100	152	--
85	30	45	77	125	--	61	116	--	--
90	39	54	84	126	--	73	131	--	--
95	47	62	89	126	--	86	148	--	--
100	55	69	91	126	35	99	--	--	--
	Years								
Merging years	--	--	--	81	--	--	--	--	--

Birch:

Below merging age: $\text{Basal area} = -214.50 - 19.17232\,S + 0.00079\,S^3 + 0.21945\,SA + 0.00192\,S^2A - 0.000025715\,S^2A^2 + 21840.0/A$

$R^2 = .933$ Basis, number of plots = 70

Above merging age: same as table 3.

$\text{Merging age} = 814.98 - 18.93519\,S + 0.11753\,S^2$

Aspen basal area $= -219.65 + 0.06441\,SA + 2903.6/A$

$R^2 = .872$ Basis, number of plots = 45

Table 6.--Average diameter of trees larger than 0.5 inch d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Inches								
20	--	--	--	--	--	1.2	1.6	2.0	2.4
25	--	--	--	--	0.7	1.4	2.0	2.5	2.9
30	0.1	1.8	2.4	2.9	0.9	1.7	2.4	3.0	3.5
35	1.5	2.4	3.0	3.5	1.2	2.1	2.8	3.5	4.2
40	2.0	2.8	3.4	3.9	1.4	2.4	3.2	4.0	4.8
45	2.5	3.2	3.8	4.4	1.7	2.8	3.7	4.6	5.4
50	2.9	3.6	4.2	4.8	2.0	3.1	4.2	5.2	6.0
55	3.2	4.0	4.6	5.2	2.3	3.5	4.6	5.6	6.7
60	3.5	4.3	5.0	5.6	2.6	3.9	5.1	6.2	7.3
65	3.8	4.6	5.3	5.9	2.9	4.3	5.5	6.7	7.9
70	4.1	4.9	5.6	6.3	3.2	4.6	6.0	7.3	--
75	4.4	5.2	6.0	6.6	3.4	5.0	6.5	7.8	--
80	4.7	5.5	6.3	6.9	3.7	5.4	6.9	8.4	--
85	4.9	5.8	6.6	7.3	4.0	5.8	7.4	--	--
90	5.2	6.1	6.9	7.6	4.3	6.2	7.9	--	--
95	5.4	6.4	7.2	7.9	4.6	6.5	8.3	--	--
100	5.7	6.6	7.5	8.2	4.9	6.9	--	--	--

Basal area of average birch tree = $-\,0.05 + 0.000042808\ SA + 0.00000021474\ SA^2$

$R^2 = .946$ Basis, number of plots = 108

Basal area of average aspen tree = $0.01 - .00073\ A + 0.000000016069\ S^2A^2$

$R^2 = .930$ Basis, number of plots = 79

Table 7.--Average diameter of trees larger than 4.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Inches								
30	--	--	--	5.0	--	--	--	4.6	4.7
35	--	--	5.0	5.2	--	--	4.9	5.0	5.2
40	--	--	5.1	5.4	--	--	5.1	5.3	5.7
45	--	5.0	5.3	5.6	--	5.1	5.4	5.7	6.2
50	--	5.2	5.5	5.8	--	5.2	5.6	6.1	6.7
55	--	5.3	5.7	6.0	--	5.4	5.9	6.5	7.3
60	--	5.4	5.8	6.3	5.0	5.5	6.2	7.0	7.8
65	5.2	5.6	6.0	6.6	5.0	5.7	6.5	7.4	8.4
70	5.3	5.7	6.3	6.8	5.0	5.8	6.8	7.8	--
75	5.4	5.9	6.5	7.1	5.0	6.0	7.1	8.3	--
80	5.5	6.1	6.7	7.4	5.1	6.2	7.4	8.7	--
85	5.6	6.2	6.9	7.7	5.1	6.4	7.8	--	--
90	5.7	6.4	7.2	8.0	5.1	6.6	8.1	--	--
95	5.9	6.7	7.4	8.3	5.2	6.8	8.5	--	--
100	6.0	6.8	7.7	8.6	5.2	7.0	--	--	--

Basal area of average birch tree = $0.11 + 0.0000000070213\ S^2A^2$

$R^2 = .937$ Basis, number of plots = 96

Basal area of average aspen tree = $0.20 - 0.000019940\ A^2 - 0.00205\ S + 0.000000017624\ S^2A^2$

$R^2 = .883$ Basis, number of plots = 65

Table 8.--Average diameter of trees larger than 6.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Inches								
30	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	6.7
40	--	--	--	6.9	--	--	--	6.9	6.9
45	--	--	--	7.1	--	--	--	7.1	7.2
50	--	--	--	7.2	--	--	--	7.4	7.6
55	--	--	7.1	7.3	--	--	7.4	7.7	8.0
60	--	--	7.2	7.5	--	--	7.6	8.0	8.5
65	--	7.0	7.3	7.6	--	7.2	7.8	8.3	8.9
70	6.9	7.1	7.4	7.8	--	7.3	8.0	8.7	--
75	7.0	7.2	7.6	8.0	--	7.4	8.2	9.0	--
80	7.0	7.3	7.7	8.2	--	7.5	8.4	9.4	--
85	7.1	7.4	7.9	8.4	--	7.6	8.6	--	--
90	7.1	7.6	8.0	8.6	--	7.6	8.8	--	--
95	7.2	7.7	8.2	8.8	--	7.6	8.1	--	--
100	7.3	7.8	8.3	9.0	--	7.7	--	--	--

Basal area of average birch tree = $0.23 + 0.0000000049723\ S^2A^2$

$R^2 = .880$ Basis, number of plots = 70

Basal area of average aspen tree = $0.27 - 0.00000024821\ A^3 - 0.00000093525\ S^2A + 0.000000024129\ S^2A^2$

$R^2 = .755$ Basis, number of plots = 45

Table 9.--Number of trees per acre larger than 0.5 inch d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Number								
20	--	--	--	--	29,300	10,000	5,840	4,037	3,026
25	--	--	--	--	24,500	7,333	4,218	2,894	2,180
30	26,000	4,777	3,025	2,381	16,500	5,378	3,143	2,174	1,640
35	5,746	2,855	2,102	1,753	11,200	4,064	2,423	1,694	1,280
40	3,243	2,039	1,604	1,383	8,009	3,173	1,927	1,358	1,030
45	2,271	1,580	1,293	1,136	5,919	2,540	1,574	1,114	845
50	1,738	1,284	1,078	960	4,606	2,085	1,311	932	707
55	1,405	1,078	921	828	3,669	1,747	1,110	790	598
60	1,172	925	801	726	3,017	1,485	951	678	512
65	1,004	808	706	644	2,523	1,279	825	588	441
70	876	715	630	576	2,147	1,115	722	513	--
75	775	640	567	521	1,855	981	637	451	--
80	692	577	514	474	1,621	870	565	398	--
85	624	524	470	434	1,430	776	504	--	--
90	566	480	431	399	1,274	697	451	--	--
95	518	441	397	368	1,141	628	405	--	--
100	476	407	368	342	1,029	569	--	--	--

Tabular values derived by dividing basal area per acre by basal area of the average tree.

Table 10.--Number of trees per acre larger than 4.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Number								
30	--	--	--	146	--	--	--	172	342
35	--	--	124	264	--	--	126	295	438
40	--	--	225	353	--	--	228	378	488
45	--	140	304	415	--	132	306	432	511
50	--	214	364	455	--	207	364	462	515
55	--	274	406	477	--	270	406	478	504
60	--	320	434	483	122	322	433	482	447
65	168	354	448	477	182	366	450	478	396
70	208	378	452	463	237	398	460	444	352
75	240	393	447	441	290	424	462	404	--
80	265	400	436	414	338	444	460	367	--
85	283	400	419	386	382	457	454	--	--
90	295	393	395	358	423	465	423	--	--
95	301	383	370	333	460	468	393	--	--
100	303	369	347	310	494	468	--	--	--

Tabular values derived by dividing basal area per acre by basal area of the average tree.

Table 11.--Number of trees per acre larger than 6.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Number								
30	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	133
40	--	--	--	89	--	--	--	78	176
45	--	--	--	105	--	--	--	120	217
50	--	--	--	143	--	--	--	161	253
55	--	--	27	189	--	--	95	197	281
60	--	--	67	235	--	--	132	230	304
65	--	20	109	276	--	47	168	258	320
70	32	54	148	308	--	84	202	280	--
75	56	88	181	330	--	122	232	300	--
80	84	121	208	341	--	159	260	315	--
85	112	150	228	328	--	195	285	--	--
90	139	175	239	314	--	232	308	--	--
95	165	194	243	300	--	270	329	--	--
100	190	208	239	287	--	308	--	--	--

Tabular values derived by dividing basal area per acre by basal area of the average tree.

Table 12.--Volume per acre of trees larger than 4.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Cubic feet								
30	--	--	--	146	--	--	--	178	479
35	--	--	162	386	--	--	196	683	1,150
40	--	--	331	767	--	--	558	1,188	1,822
45	--	68	588	1,213	--	203	918	1,692	2,494
50	--	232	891	1,680	--	445	1,280	2,196	3,166
55	--	433	1,209	2,139	--	686	1,641	2,701	3,837
60	--	651	1,523	2,570	12	928	2,002	3,206	4,509
65	112	872	1,822	2,961	16	1,170	2,364	3,710	5,180
70	282	1,087	2,094	3,302	30	1,412	2,724	4,214	--
75	455	1,290	2,334	3,586	45	1,654	3,086	4,718	--
80	625	1,474	2,531	3,808	60	1,896	3,447	5,223	--
85	790	1,636	2,695	3,964	74	2,138	3,808	--	--
90	946	1,774	2,809	4,052	89	2,379	4,169	--	--
95	1,090	1,884	2,876	4,067	104	2,621	4,530	--	--
100	1,220	1,964	2,894	4,009	118	2,862	--	--	--

Birch volume $= -7948.94 + 61.41655\,A - 1.61343\,S^2 + 0.06543\,S^2A - 0.00040\,S^2A^2 + 188900.0/A$

$R^2 = .966$ Basis, number of plots = 96

Aspen volume $= -1538.12 - 0.00477\,S^3 + 0.02388\,S^2A$

$R^2 = .945$ Basis, number of plots = 65

Table 13.--Volume per acre of trees larger than 6.5 inches d.b.h.

Age (years)	Birch site index (feet)				Aspen site index (feet)				
	35	45	55	65	35	45	55	65	75
	Cubic feet								
30	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	314
40	--	--	--	374	--	--	--	198	718
45	--	--	--	578	--	--	--	518	1,178
50	--	--	--	782	--	--	--	876	1,690
55	--	--	249	987	--	--	454	1,271	2,256
60	--	--	395	1,191	--	--	732	1,704	2,877
65	--	110	542	1,395	--	131	1,034	2,175	3,552
70	107	208	688	1,600	--	312	1,361	2,684	--
75	166	306	834	1,804	--	508	1,712	3,230	--
80	225	404	980	2,008	--	717	2,086	3,814	--
85	284	502	1,127	2,212	--	940	2,485	--	--
90	344	600	1,273	2,417	--	1,176	2,908	--	--
95	403	698	1,419	2,621	--	1,425	3,355	--	--
100	462	796	1,565	2,825	--	1,688	--	--	--

Birch volume = $1950.64 - 87.38303\ S + 0.00899\ S^3 + 0.00967\ S^2A$

$R^2 = .922$ Basis, number of plots = 70

Aspen volume = $-1007.82 - 0.00661\ SA^2 + 0.00028\ S^2A^2$

$R^2 = .902$ Basis, number of plots = 45

Table 14.--Relative diameter distribution of aspen trees by average diameter of all trees in the stand larger than 0.5 inch d.b.h.

Average stand d.b.h. 1/ (inches)	Diameter class (inches) 1/													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Percent of trees in stand													
2	36	41	19	4										
3	7	35	33	18	6	1								
4	1	14	30	27	17	9	2							
5		5	17	26	21	18	9	3	1					
6		1	9	17	21	20	16	11	4	1				
7			4	10	17	19	18	15	10	5	2			
8			1	6	12	15	16	16	14	10	7	2	1	
9				3	8	11	14	16	14	14	9	6	3	2

1/ Midpoint of class (e.g. 5 = 4.6 through 5.5 inches).

Table 15.--Relative diameter distribution of birch trees by average diameter of all trees in the stand larger than 0.5 inch d.b.h.

Average stand d.b.h.1/ (inches)	Diameter class (inches) 1/												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2	46	34	18	2									
3	10	34	33	18	5								
4	1	13	30	29	20	6	1						
5		3	15	26	28	18	8	2					
6			5	15	24	24	19	10	3				
7			1	6	15	21	24	18	10	4	1		
8				2	7	14	20	23	17	11	6		
9					3	8	14	18	20	17	11	7	2

1/ Midpoint of class (e.g. 5 = 4.6 through 5.5 inches).

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Gregory, Robert A., and Haack, Paul M.
1965. Growth and yield of well-stocked aspen & birch stands in Alaska. Northern Forest Expt. Sta., Juneau, Alaska. 27 pp., (U. S. Forest Serv. Res. Paper, NOR-2).

Presents normal yield tables for well-stocked, even-aged stands of quaking aspen (*Populus tremuloides* Michx.) and paper birch (*Betula papyrifera* Marsh.) in interior Alaska.

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